CFOSAT Second International Science Team Meeting

On the First Observed Wave-Induced Stress over the Global Ocean

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2021/03/16

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CONTENTS

Background and Aims

Wave Climate

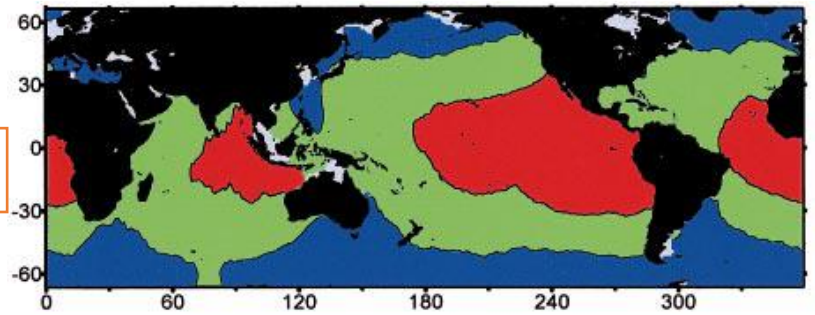
Ocean waves: fundamental and ubiquitous phenomenon

Influence: human life, industrial activities

Importance: geophysical processes, momentum exchange

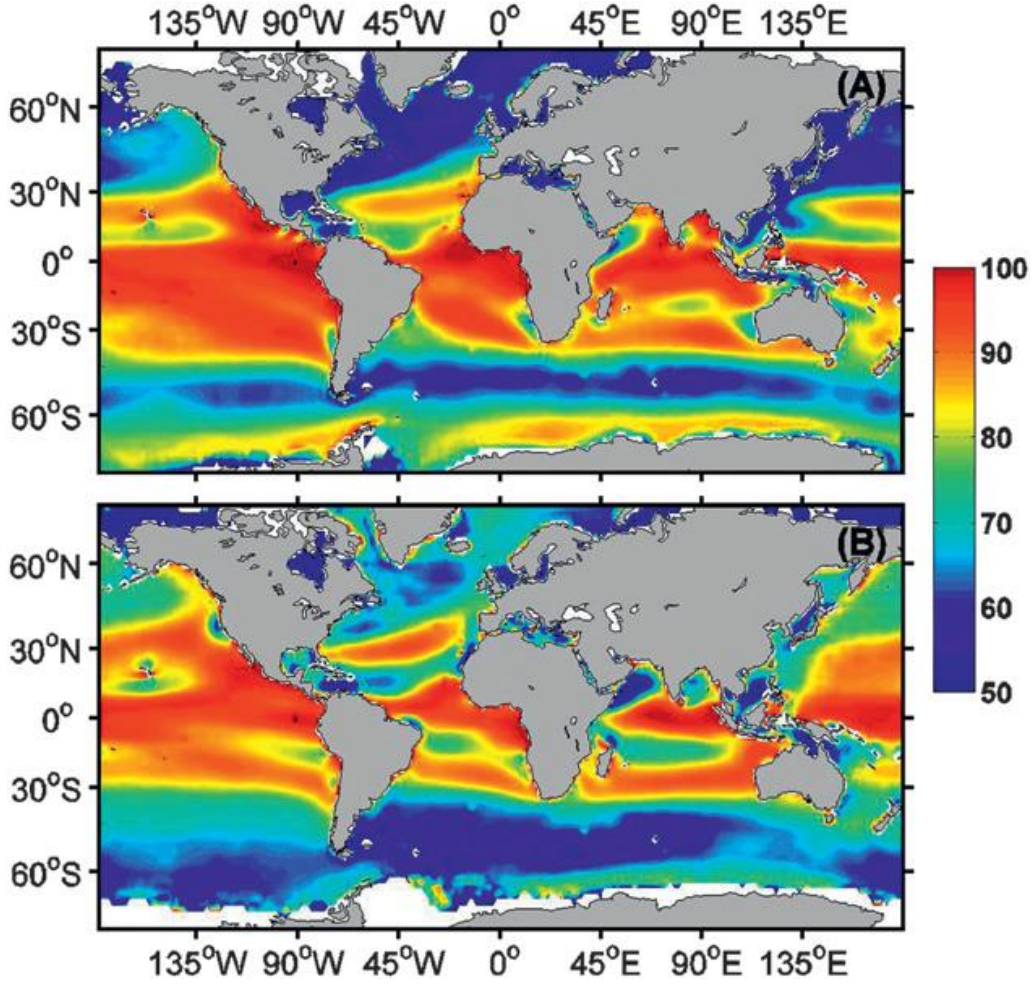
Study: both societal and scientific perspectives.

Swell Pool



TOPEX/NSCAT&QSCAT:
Wind & Significant wave height
(Chen G. et al. 2002)

Swell Dominance



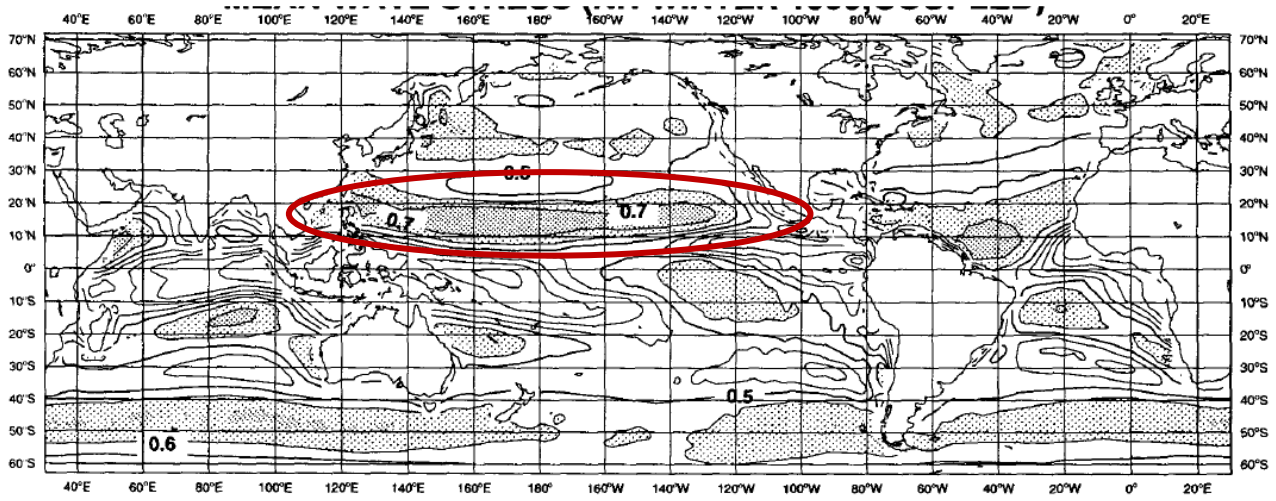
ERA-40: Wave Spectra
(Semedo et al. 2011)

Background and Aims

Wave-Induced Stress

$$\tau_w = \rho_w g \int d\omega d\theta S_{in}/c \qquad \tau_w(0) = \int_0^\infty \rho_w \omega \beta \Phi(\omega)\, d\omega$$

NH Winter

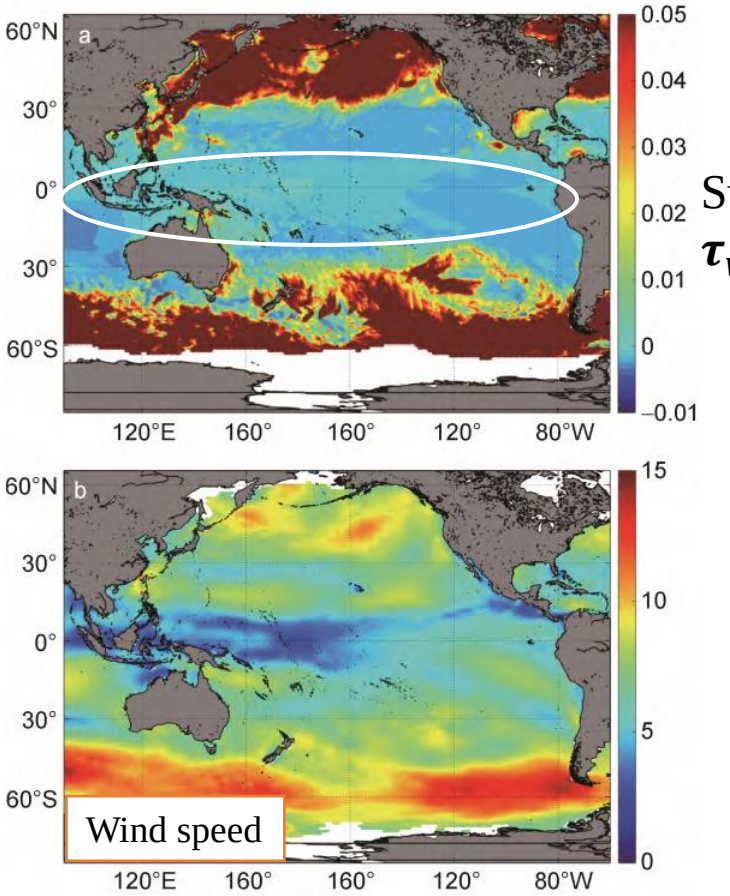


τ_w/τ: maximum 0.7

(Janssen & Viterbo, 1995)

NH Winter

Pacific: wave-induced stress



Swell: $\tau_w < 0$

ERA-interim:
Wind & Wind-sea and Swell Significant Height
(Wang et al. 2018)

Background and Aims

Our Aims

Wind & Wave spectra

(1) Global ocean: surface wave-induced stress

(2) Surface wind stress inversion

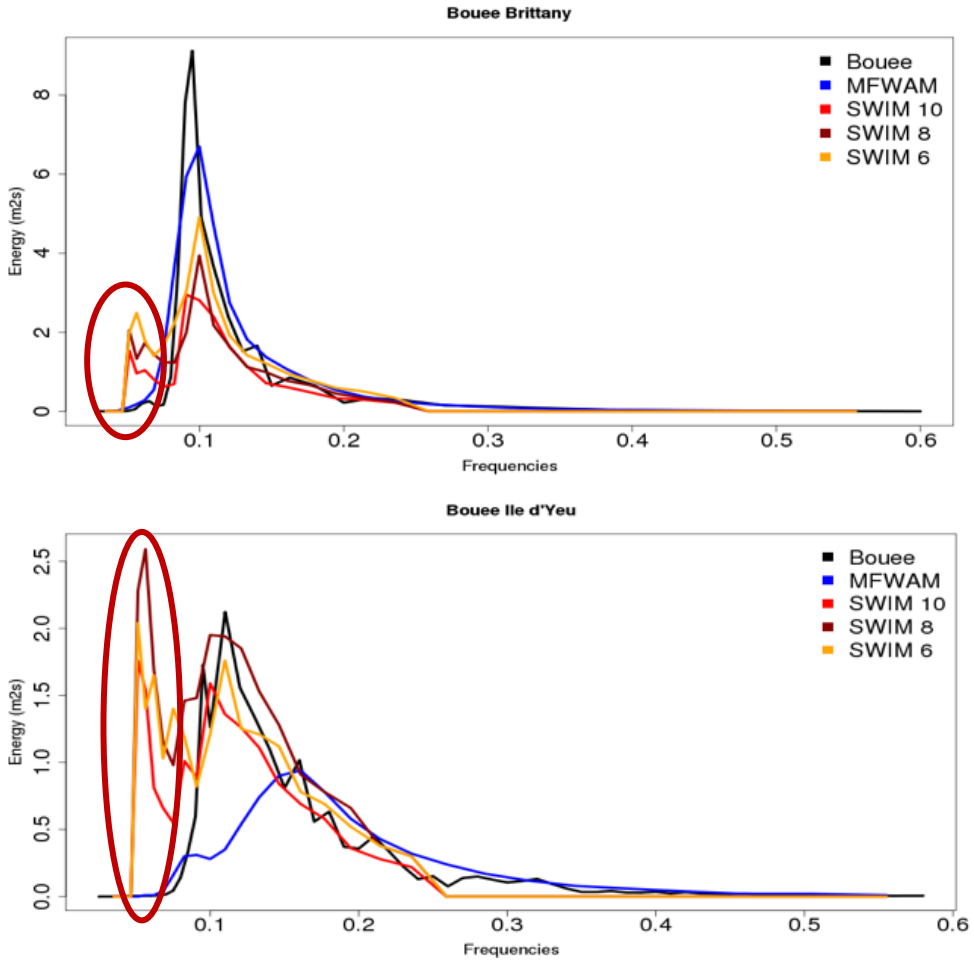
02 Wind and Wave Data Process

Data Process

Datasets: 2019.8-2019.11, 4 months

Wave spectra: beam 10°

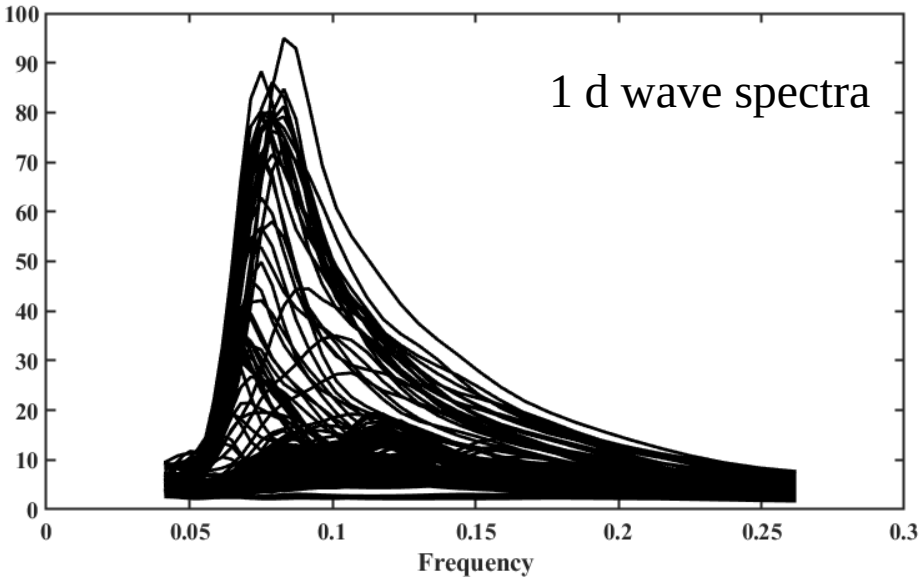
Step 1: Wavenumber range



Low frequency: Parasitic peak

Possible maximum period of swell: 25 s

Wavenumber: k_{min} =0.0065 m^{-1}



(Hauser et al. 2020)

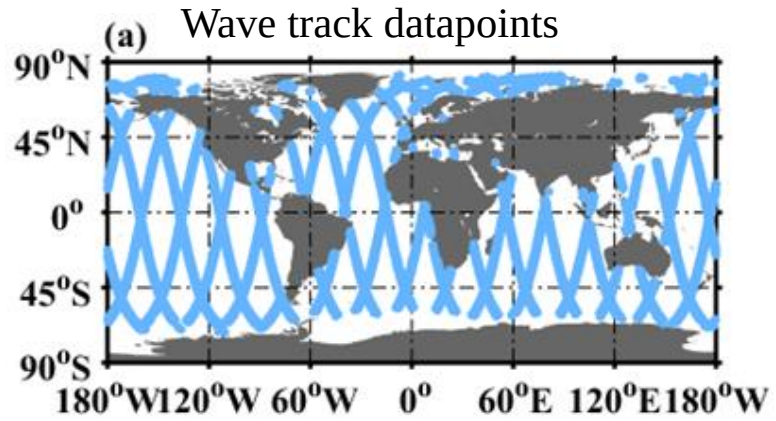
Data Process

Step 2: Wind and wave cell match

Global coverage

SWIM-Wave: 13 days

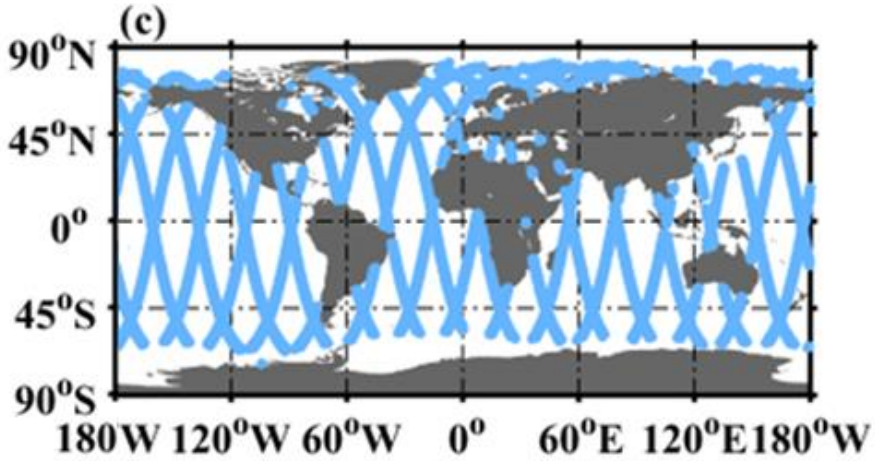
SCAT-Wind: 3 days



1. **Time**: T_{SWIM} - 4 s < T_{SCAT} < T_{SWIM} + 4 s

(Each moment: wave cell⟺42 or 84 wind cell)

2. **Longitude & Latitude**: Sum of the difference between wind and wave cell in longitude plus that in latitude is the minimum

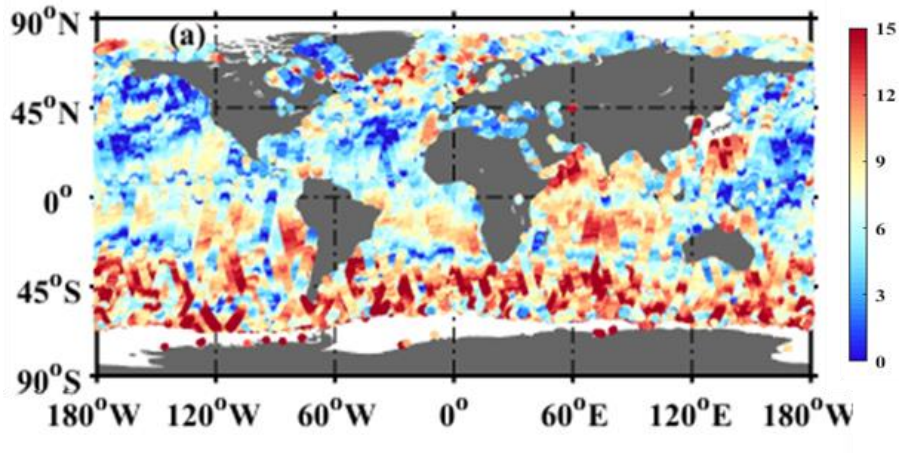


Match of Wind datapoints

Data Process

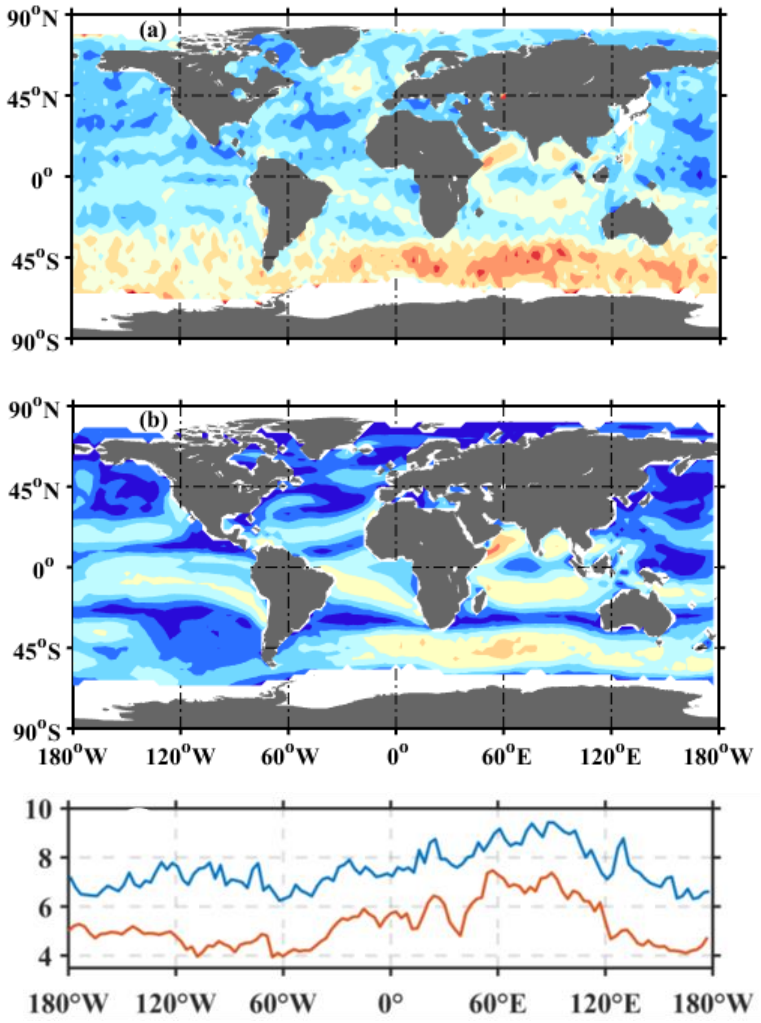
Step 3: Grid the data

13-day wind speed pattern



overlapping effect: indistinct

3°×3°: monthly average



⇦ CFOSAT

⇦ ERA5

Meridional mean

Correlation: 0.83

Difference: ~30%

03 Results and Discussions

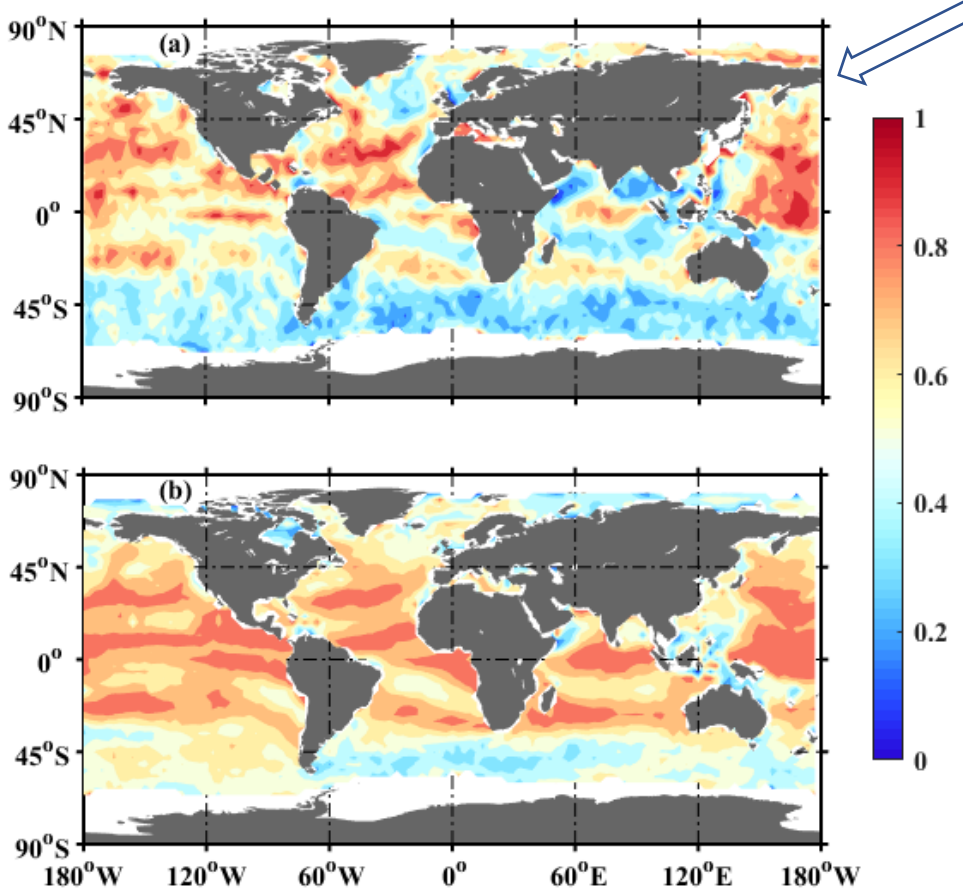
Results and Discussions

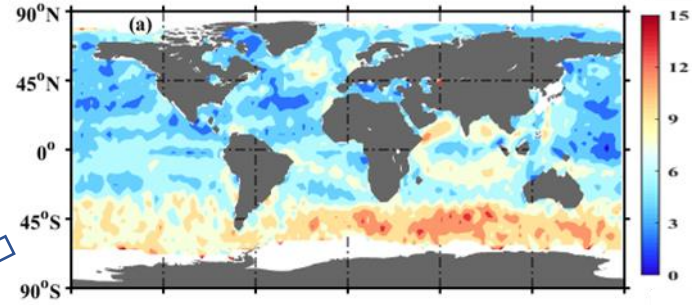
Swell index (*SI*) $SI = \frac{E_{swell}}{E_{tot}}$

CFOSAT

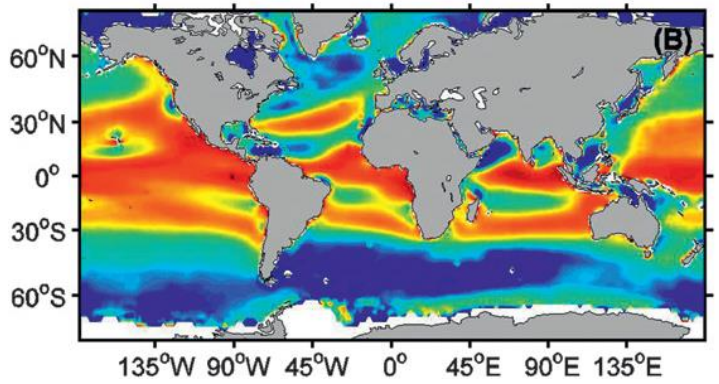
ERA5

August





June-August

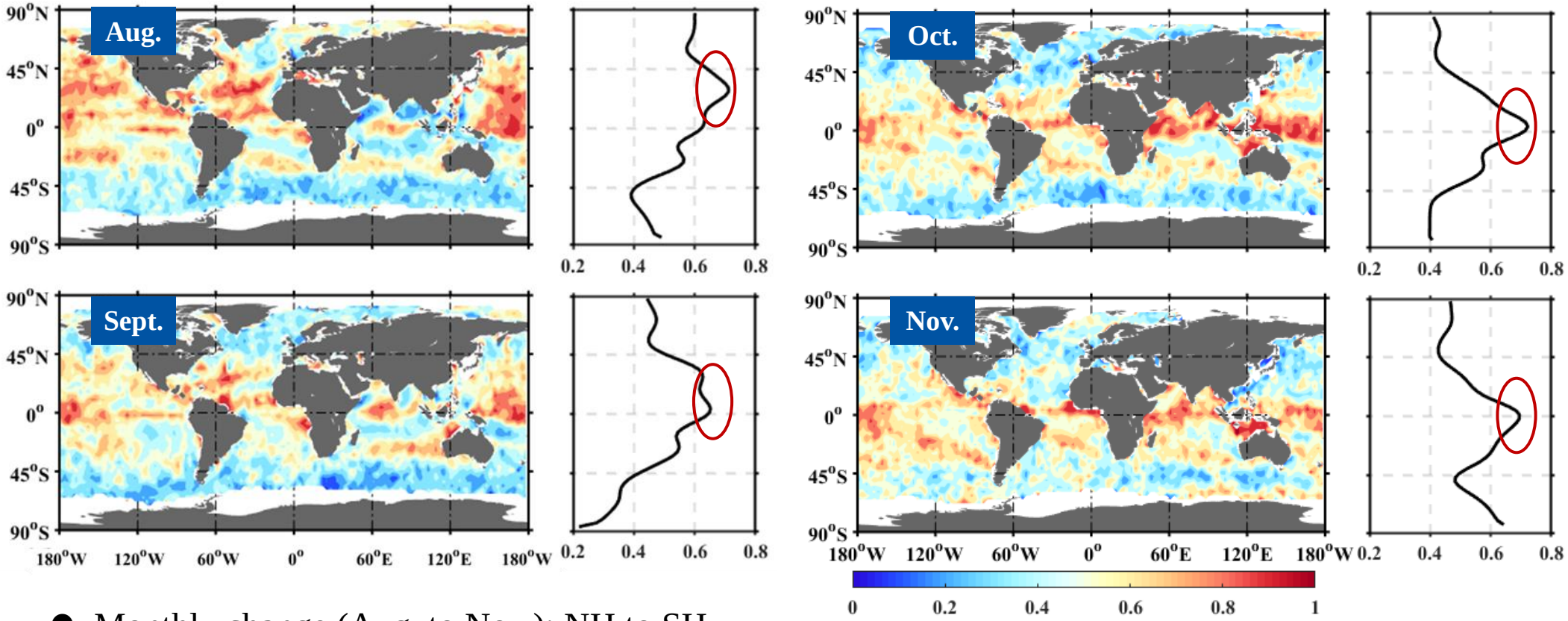


Semedo et al. 2011(ECMWF)

Results and Discussions

Swell index (*SI*)

Monthly variation



- Monthly change (Aug. to Nov.): NH to SH
- Close to the equator: swell energy > 60%

Results and Discussions

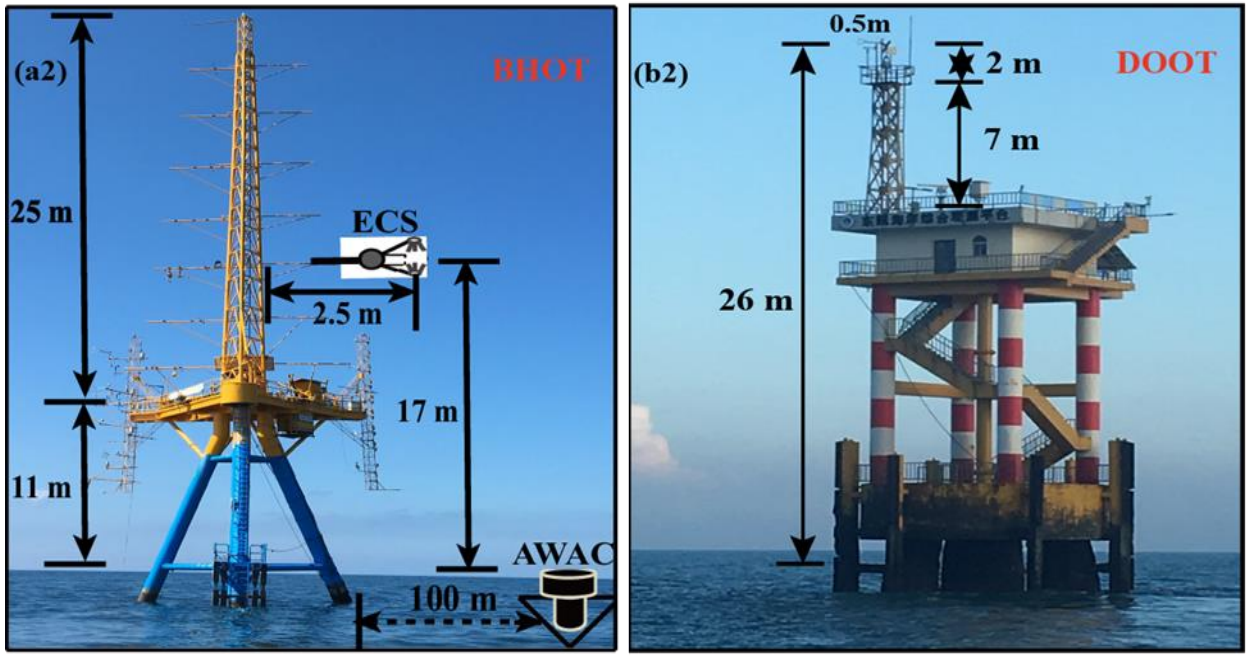
Wave-induced stress $\tau_{wave0}/u_*^2 = \int_{0.0065}^{0.277} \frac{C_\beta g k}{c^2} E(k) dk$

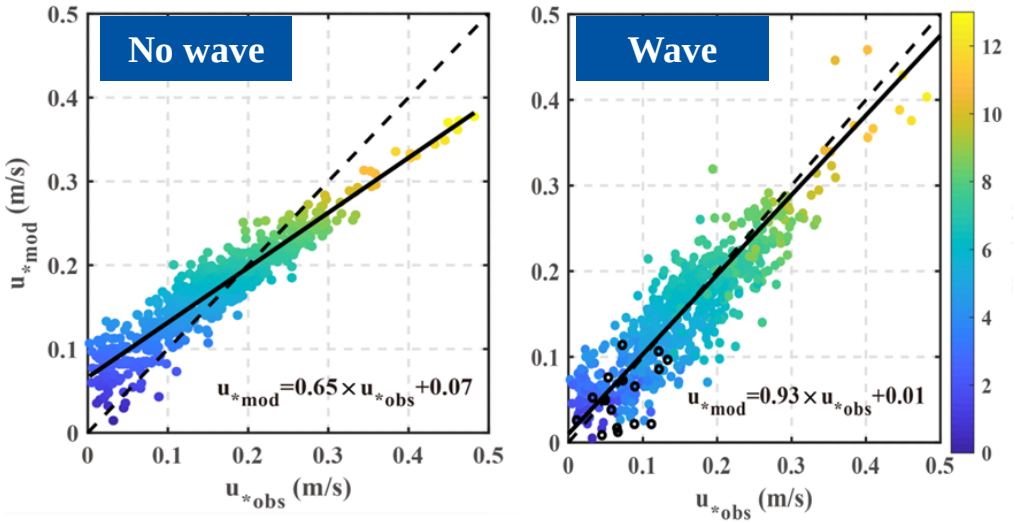
Wave growth/decay rate coefficient C_β??

C_β= 16: Wind-sea part

C_β= -30: Swell part

$c = 1.2\,U_{10}$





(Chen S. et al. 2019, JPO)

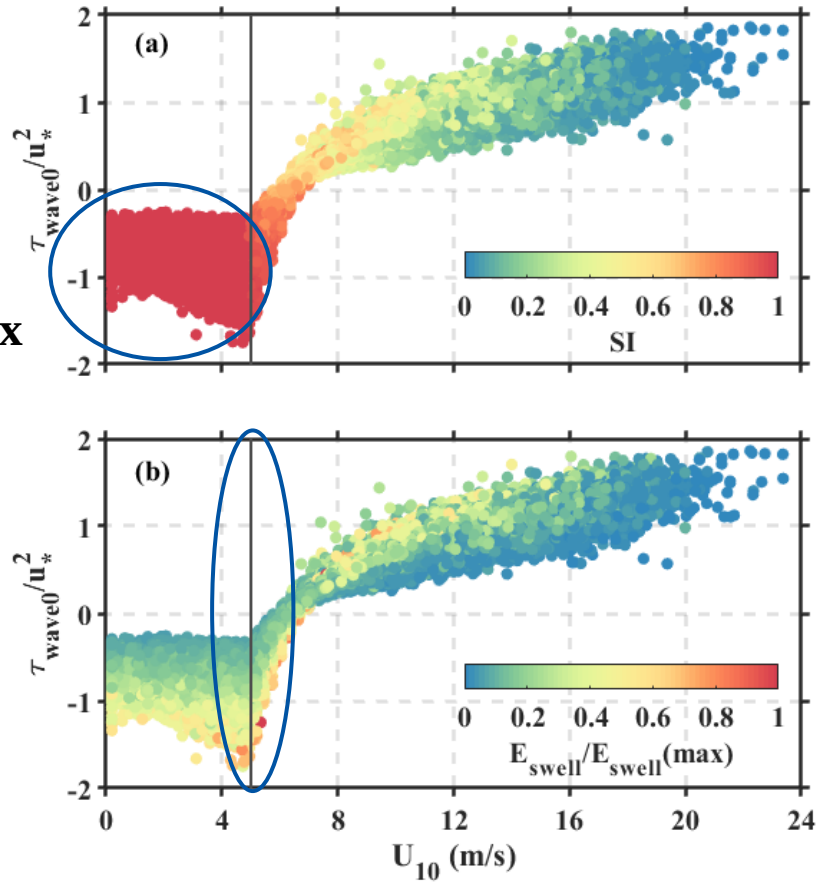
Results and Discussions

Wave-induced stress

Upward momentum flux

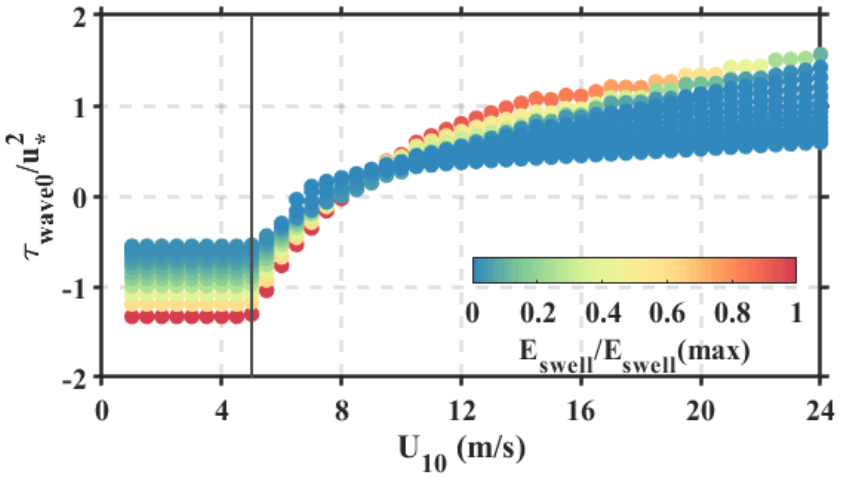
Critical wind speed ~5 m/s

CFOSAT: August



Wind-sea spectrum: $S(f) = \frac{\alpha g^2 f^{-4}}{(2\pi)^4} f_p^{-1} \exp(-\left(\frac{f_p}{f}\right)^4)\gamma^{\Gamma}$

Swell spectrum: $S(f) = S(f)\exp[\left(\frac{f}{f_0}\right)^3]$ (Donelan et al. 1985)



Maximum wavenumber:

k_{cmax} =0.277 m^{-1} $\Longrightarrow$ f_{cmax} =0.2622 Hz

$U_{10c} = 0.83\,g/(2\pi f_{cmax})$

Results and Discussions

Wave-induced stress

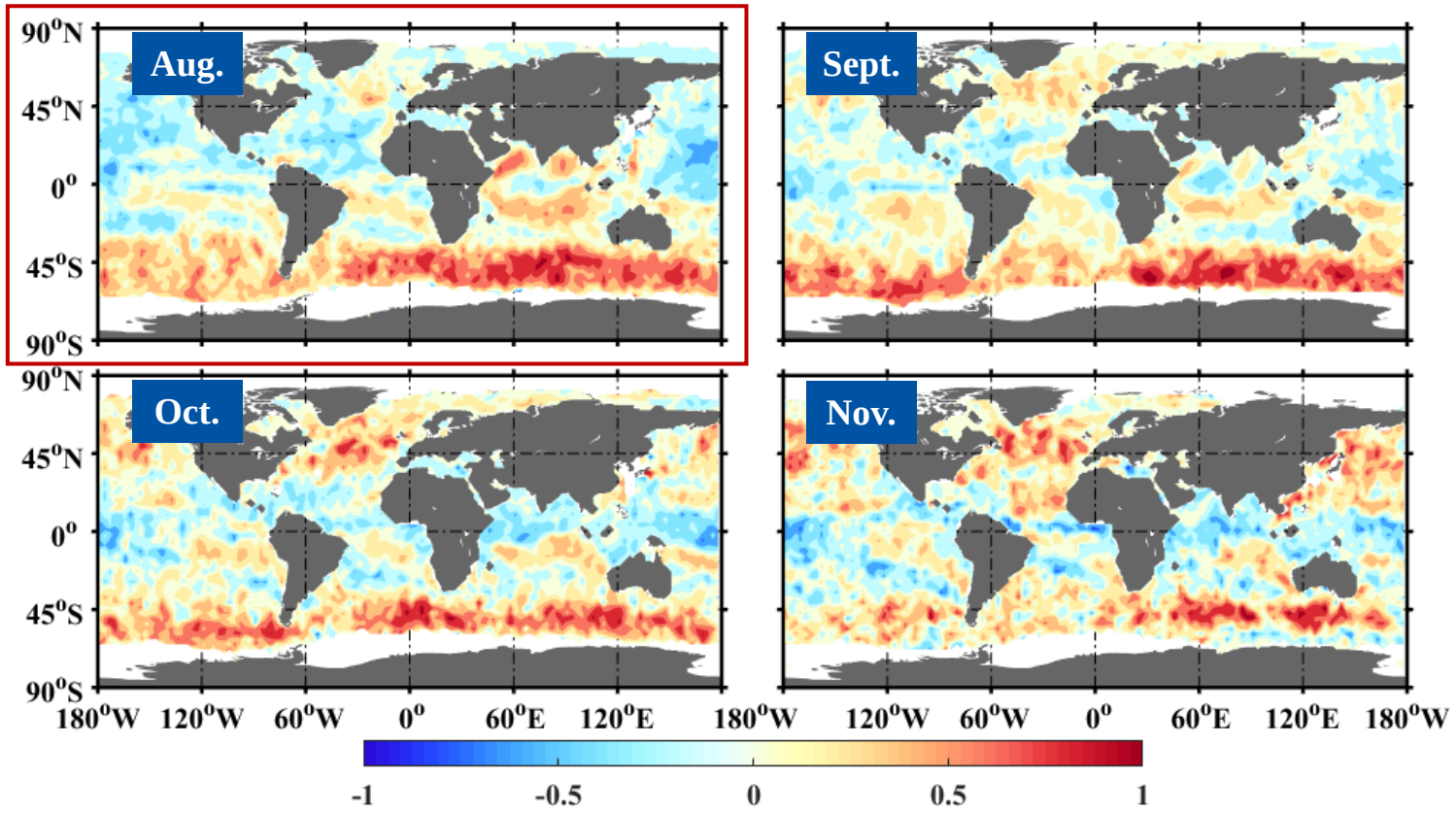
Later summer

- Indian Ocean monsoon zone
- Westerlies of the SH

$\tau_w < 0$

- Aug. to Nov.: 50% to 27% for NH
- Close to equator: ~ 60%

Monthly mean

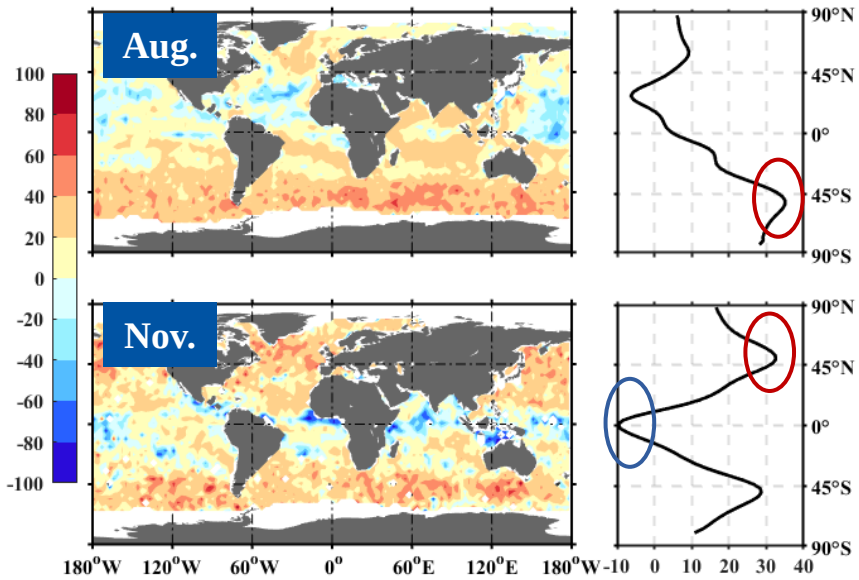


Factor : wind and wave fields

Results and Discussions

Wind stress $\tau = \tau_{turb} + \tau_{wave}$

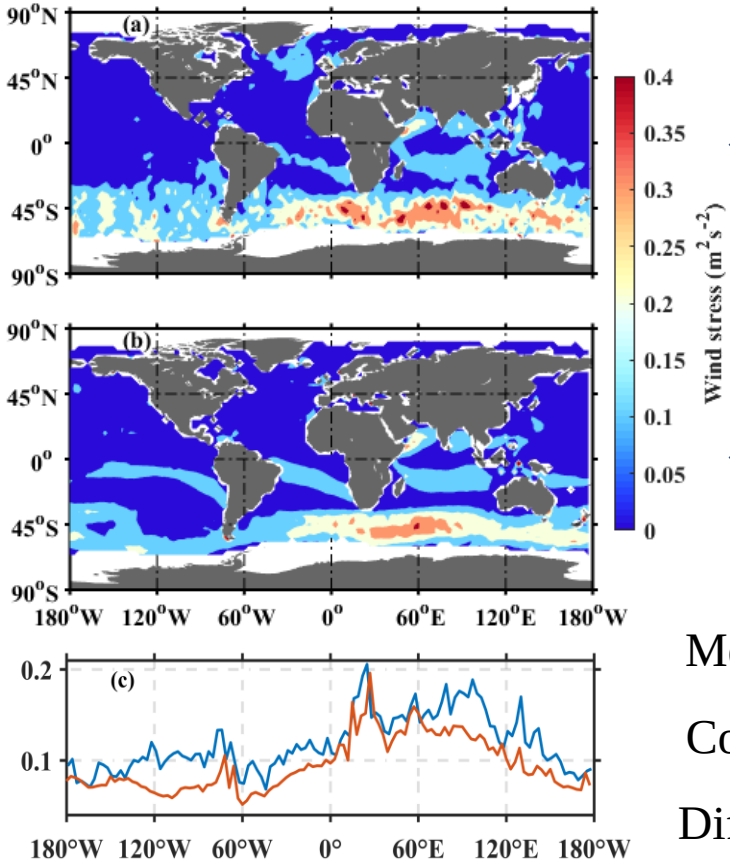
Percentage of increase or decrease in wind stress



+ 30% (Wind-sea)

- 10% (Swell)

Aug.: Comparison with ERA5



⇦ CFOSAT

⇦ ERA5

Meridional mean

Correlation: 0.85

Difference: ~20%

Conclusions

GOAL

(1) Global ocean: surface wave-induced stress

(2) Surface wind stress inversion

- For the first time CFOSAT realizes the inversion of the surface wave-induced stress, and then the wind stress.
- The wave-induced stress can increase zonal mean wind stress by more than 30%.
- The temporal and spatial variations of wave-induced stress are closely related to the global wind and wave fields.

THANKS!

Chen, S., Rutgersson, A., Yin, X., Xu, Y., Qiao, F. (2020). On the First Observed Wave-induced Stress over the Global Ocean. ***Journal of Geophysical Research: Oceans***, e2020JC016623. doi:10.1029/2020JC016623